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ABSTRACT

The United States Training and Employment Service General Aptitude Test Battery (GATB), first published in 1947, has been included in a continuing program of research to validate the tests against success in many different occupations. The GATB consists of 12 tests which measure nine aptitudes: General Learning Ability; Verbal Aptitude; Numerical Aptitude; Spatial Aptitude; Form Perception; Clerical Perception; Motor Coordination; Finger Dexterity; and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, and a standard deviation of 20. Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, when combined, predict job performance. Cutting scores are set only for those aptitudes which aid in predicting the performance of the job duties of the experimental sample. The GATB norms described are appropriate only for jobs with content similar to that shown in the job description presented in this report. A description of the validation sample and a personnel evaluation form are also included. (AG)

March 1968 United States Employment Service Technical Report S-316

S-316

ED 066478

Development of USES Aptitude Test Battery

for

Programmer, Engineering and Scientific

(profess. & kin.) 020.188

TM 001 962

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U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION

Technical Report on Development of USES Aptitude Test Battery

For . . . . .

Programmer, Engineering and Scientific (profess. & kin.) 020.188
S-316

(Developed in Cooperation with the
California and Ohio State Employment Services)

U.S. DEPARTMENT OF LABOR
Willard Wirtz, Secretary

MANPOWER ADMINISTRATION
Stanley H. Ruttenberg,
Administrator

BUREAU OF EMPLOYMENT SECURITY
Robert C. Goodwin, Administrator

U.S. EMPLOYMENT SERVICE
Charles E. Odell,
Director

March 1968

FOREWORD

The United States Employment Service General Aptitude Test Battery (GATB) was first published in 1947. Since that time the GATB has been included in a continuing program of research to validate the tests against success in many different occupations. Because of its extensive research base the GATB has come to be recognized as the best validated multiple aptitude test battery in existence for use in vocational guidance.

The GATB consists of 12 tests which measure 9 aptitudes; General Learning Ability, Verbal Aptitude, Numerical Aptitude, Spatial Aptitude, Form Perception, Clerical Perception, Motor Coordination, Finger Dexterity, and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, with a standard deviation of 20.

Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, in combination, predict job performance. For any given occupation, cutting scores are set only for those aptitudes which contribute to the prediction of performance of the job duties of the experimental sample. It is important to recognize that another job might have the same job title but the job content might not be similar. The GATB norms described in this report are appropriate for use only for jobs with content similar to that shown in the job description included in this report.

Charles E. Odell, Director
U.S. Employment Service

GATB Study # 2527, 2698

DEVELOPMENT OF USES APTITUDE TEST BATTERY

FOR

Programmer, Engineering and Scientific (profess. & kin.) 020.188-030
S-316

This report describes research undertaken for the purpose of developing General Aptitude Test Battery (GATB) norms for the occupation of Programmer, Engineering and Scientific (profess. & kin.) 020.188-030. The following norms were established:

GATB Aptitudes	Minimum Acceptable GATB Scores
G - General Learning Ability	125
V - Verbal Aptitude	110
N - Numerical Aptitude	110
S - Spatial Aptitude	105

RESEARCH SUMMARY - VALIDATION SAMPLE

Sample:
72 (62 male and 10 female) workers employed as Engineering and Scientific Programmers at various establishments in California.

Criterion:
Supervisory ratings.

Design:
Concurrent (test and criterion data were collected at approximately the same time).

Minimum aptitude requirements were determined on the basis of a job analysis and statistical analyses of aptitude mean scores, standard deviations, aptitude criterion correlations and selective efficiencies.

Concurrent Validity:
Phi Coefficient = .47 P/2 $<$.0005

Effectiveness of Norms:
Only 68% of the nontest-selected workers used for this study were good workers: if the workers had been test-selected with the above norms, 83% would have been good workers. 32% of the nontest-selected workers used for this study were poor workers; if the workers had been test-selected with the above norms, only 17% would have been poor workers. The effectiveness of the norms is shown graphically in Table 1:

TABLE 1

Effectiveness of Norms

	Without Tests	With Tests
Good Workers	68%	83%
Poor Workers	32%	17%

VALIDATION SAMPLE DESCRIPTION

Size:
N = 72

Occupational Status:
Employed workers.

Work Setting:
Workers were employed at the Aerojet General Corporation, Azusa; Aeronutrics Corporation, Newport Beach; Aerospace Corporation, El Segundo; Aerospace Corporation, San Bernardino; Jet Propulsion Laboratories, Pasadena; Tidewater Oil Company, Los Angeles.

Employer Selection Requirements:
Education: College degree in mathematics, physics, or engineering.

Previous Experience: None required.

Tests: Aerojet General Corporation administers the IBM Programmer Aptitude Test but the test results are not considered as being conclusive in hiring.

Other: Standard employment form and interview with both a Personnel Department interviewer and a supervisor in the Computing Department.

Principal Activities:
The job duties for each worker are comparable to those shown in the job description on the Fact Sheet.

Minimum Experience:
All workers in the sample had at least five months total job experience.

TABLE 2

Means, Standard Deviations (SD), Ranges, and Pearson Product-Moment Correlations with the Criterion (r) for Age, Education, and Experience

	M	SD	Range	r
Age (years)	29.6	6.1	22-58	-.160
Education (years)	16.5	1.1	14-20	.155
Experience (months)	37.5	24.3	5-120	.097

EXPERIMENTAL TEST BATTERY

All 12 tests of the GATB, B-1002B, were administered during the period June 1962 to January 1964.

CRITERION

The criterion data consisted of supervisory ratings of job proficiency made at approximately the same time as test data were collected. The worker's fist-line supervisor made two ratings with a time interval of at least two weeks between ratings.

Rating Scale:
An adaptation of USES Form SP-21 "Descriptive Rating Scale". (See Appendix) This scale consisted of ten items covering different aspects of job performance. Each item has five alternatives corresponding to different degrees of job proficiency.

Reliability:
The coefficient of reliability between the two ratings is .90 indicating a significant relationship. Therefore, the final criterion consisted of the combined scores of the two sets of ratings.

Criterion Distribution:

Possible Range:	20-100
Actual Range:	38-98
Mean:	68.0
Standard Deviation:	13.3

Criterion Dichotomy:
The criterion distribution was dichotomized into high and low groups by placing 32% of the sample in the low criterion group to correspond with the percentage of workers considered unsatisfactory or marginal. Workers in the high criterion group were designated as "good workers" and those in the low group as "poor workers." The criterion critical score is 63.

APTITUDES CONSIDERED FOR INCLUSION IN THE NORMS

Aptitudes were considered for tryout in the norms on the basis of a qualitative analysis of the job duties involved and a statistical analysis of test and criterion data. Aptitudes S and Q which do not have a high correlation with the criterion were considered for inclusion in the norms because the qualitative analysis indicated they were important to the job duties and the sample had a relatively high mean score and a relatively low standard deviation on these aptitudes. With employed workers a relatively high mean score or relatively low standard deviation may indicate that some sample pre-selection has taken place. Tables 3, 4, and 5 show the results of the qualitative and statistical analyses.

TABLE 3

Qualitative Analysis

(Based on the analysis of the job duties, the aptitudes listed below appear to be important for job success.)

Aptitude	Rationale
G - General Learning Ability	Required to learn, understand, and apply programming principles and techniques. Ability to learn functions and applications of data-processing equipment. Ability to learn and work with advanced mathematical principles and methodology to solve complex scientific and engineering problems. Ability to reason and make decisions based upon analysis of data. Ability to identify, analyze, and organize mathematical or technical elements of a problem into logical sequence for computer processing. Ability to translate elements or terms of a problem into synthetic machine language for computer direction and to prepare instructions for console operation. Ability to check program for accuracy and completeness, including computer operation.

Aptitude	Rationale
V - Verbal Aptitude	Required to read and understand work statements, procedural routines, and related data. Ability to intelligently participate in briefing and conferences with person or persons involved in assigned project and to discuss procedural problems or to obtain additional information. Ability to prepare written reports or to present oral reports as directed. Ability to document results of analysis, develop plans, and prepare instructions for console operators. Ability to read technical literature in order to keep current in new developments.
N - Numerical Aptitude	Ability to identify mathematical formulas, tables, and reference materials. Ability to compute mathematical formulas and equations which include linear algebra, vector analysis, differential equations, and calculus. Ability to prepare accurate input and output data lists and to compile a nomenclature list containing symbols, descriptions, and units of measures for each mathematical element in a problem.
S - Spatial Aptitude	Ability to mentally visualize flow of data through a computer system and to develop block diagrams and flow charts. Ability to conceive spatial relationships which may occur between elements of scientific or engineering problems.
Q - Clerical Perception	Required to perceive pertinent detail in program documentation, assembled data, and recommended routines. Required to prepare input, output, and nomenclature lists. Required to translate flow chart steps and prepare instructions for console operations. Required to detect errors in program instructions and to avoid perceptual errors in making computations.

TABLE 4

Means, Standard Deviations (SD), Ranges, and Pearson Product-Moment Correlations with the Criterion (r) for the Aptitudes of the GATB

Aptitude	Mean	SD	Range	r
G - General Learning Ability	135.3	12.5	104-166	.269*
V - Verbal Aptitude	128.4	14.3	96-162	.242*
N - Numerical Aptitude	130.2	13.2	98-157	.263*
S - Spatial Aptitude	123.9	14.3	88-153	.150
P - Form Perception	122.0	19.6	87-170	.151
Q - Clerical Perception	129.1	13.9	90-160	.185
K - Motor Coordination	117.8	16.8	60-155	.214
F - Finger Dexterity	99.3	18.4	56-148	.170
M - Manual Dexterity	113.0	21.5	61-168	.255*

*Significant at the .05 level

TABLE 5

Summary of Qualitative and Quantitative Data

Type of Evidence	Aptitudes								
	G	V	N	S	P	Q	K	F	M
Job Analysis Data									
Important	X	X	X	X		X			
Irrelevant									
Relatively High Mean	X	X	X			X			
Relatively Low Standard Deviation	X	X	X	X		X			
Significant Correlation with Criterion	X	X	X						X
Aptitudes to be Considered for Trial Norms	G	V	N	S		Q			M

DERIVATION AND VALIDITY OF NORMS

Final norms were derived on the basis of a comparison of the degree to which trial norms consisting of various combinations of Aptitudes G, V, N, S, Q, and M at trial cutting scores were able to differentiate between the 68% of the sample considered good workers and the 32% of the sample considered poor workers. Trial cutting scores at five-point intervals approximately one standard deviation below the mean are tried because this will eliminate about one-third of the sample with three-aptitude norms. For two-aptitude trial norms, minimum cutting scores of slightly more than one standard deviation below the mean will eliminate about one-third of the sample; for four-aptitude trial norms, cutting scores slightly less than one standard deviation below the mean will eliminate about one-third of the sample. The Phi Coefficient was used as a basis for comparing trial norms. The optimum differentiation for the occupation of Programmer, Engineering and Scientific 020.188-030 was provided by norms of G-125, V-110, N-110, and S-105. The validity of these norms is shown in Table 6 and is indicated by a Phi Coefficient of .47 (statistically significant at the .0005 level).

TABLE 6

Concurrent Validity of Test Norms, G-125, V-110, N-110, and S-105

	Nonqualifying Test Scores	Qualifying Test Scores	Total
Good Workers	6	43	49
Poor Workers	14	9	23
Total	20	52	72

Phi Coefficient (ϕ) = .47 Chi Square (χ^2_{xy}) = 16.1

Significance Level = P/2 $<$ .0005

DETERMINATION OF OCCUPATIONAL APTITUDE PATTERN

The data for this study did not meet the requirements for incorporating the occupation studied into any of the 36 OAP's included in Section II of the Manual for the General Aptitude Test Battery. The data for this sample will be considered for future groupings of occupations in the development of new occupational aptitude patterns.

S-316

Programmer, Engineering and Scientific (profess. and kin.) 020.188-030

Check Study Research Summary

Sample:
45 male workers and 14 female workers employed as **Scientific Programmers by** various firms and governmental agencies in Ohio.

TABLE 7

Means, Standard Deviations (SD), Ranges and Pearson Product-Moment Correlations with the Criterion (r) for Age, Education and Experience-Cross-Validation Sample

	Mean	SD	Range	r
Age (years)	31.8	6.6	23-48	-.020
Education (years)	16.6	1.2	14-20	.242
Experience (months)	68.7	49.0	24-232	.091

Criterion:
Supervisory ratings.

Design:
Concurrent (test and criterion data were collected at approximately the same time).

Principal Activities:
The duties for this sample are comparable to those shown in the job description in the Appendix.

Concurrent Validity:
Phi Coefficient (ϕ) = .27 ($P/2 < .025$)

Effectiveness of Norms:
Only 71% of the non-test-selected workers used for this study were good workers; if the workers had been test-selected with the **S-316** norms, 81% would have been good workers. 29% of the non-test-selected workers used for this study were poor workers; if the workers had been test-selected with the **S-316** norms, only 19% would have been poor workers. The effectiveness of the norms is shown graphically in Table 8.

TABLE 8

Effectiveness of S-316 Norms on Check Study Sample

	Without Tests	With Tests
More Proficient Workers	71%	81%
Less Proficient Workers	29%	19%

Means, Standard Deviations (SD), Ranges, and Pearson Product-Moment Correlations with the Criterion (r) for the Aptitudes of the GATB; N = 59

	Mean	SD	Range	r
G - General Learning Ability	136.6	15.0	93-164	.484**
V - Verbal Aptitude	128.2	16.2	90-168	.395**
N - Numerical Aptitude	131.7	15.6	94-159	.404**
S - Spatial Aptitude	124.6	15.9	81-163	.279*
P - Form Perception	117.6	17.8	84-156	.170
Q - Clerical Aptitude	129.1	20.4	87-196	.285*
K - Motor Coordination	119.6	19.2	78-151	.199
F - Finger Dexterity	102.8	21.9	66-157	.210
M - Manual Dexterity	100.8	20.9	69-155	.070

* significant at the .05 level
** significant at the .01 level

TABLE 9

Concurrent Validity of S-316 Norms
(G-125, V-110, N-110, S-105)
Check Study Sample

	Nonqualifying Test Scores	Qualifying Test Scores	Total
More Proficient Workers	9	33	42
Less Proficient Workers	9	8	17
Total	18	41	59

Phi Coefficient (ϕ) = .27
Significance Level = $P/2 < .025$

Chi Square (X^2_y) = 4.3

SP-21

(Adaption)

DESCRIPTIVE RATING SCALE
(For Aptitude Test Development Studies)

Score_____

RATING SCALE FOR _____
D.O.T. Title and Code

Directions: Please read Form SP-20, "Suggestions to Raters" and then fill in the items listed below. In making your ratings, only one box should be checked for each question.

Name of employee_____
(Last) (First) (Initial)

Sex: Male_____ Female_____

Company Job Title: _____

How often do you see this employee in a work situation?

( ) See him at work all the time.

( ) See him at work several times a day.

( ) See him at work several times a week.

( ) Seldom see him in work situation.

How long have you supervised him?

( ) Under one month.

( ) One to two months.

( ) Three to five months.

( ) Six months or more.

A. How much work can he accomplish? (Ability to make efficient use of his time.

( ) Capable of low work output. Can perform only at a less than satisfactory rate.

( ) Capable of fair work output. Can perform at a satisfactory rate.

( ) Capable of good work output. Can perform at a fast rate.

( ) Capable of high work output. Can perform at a very fast rate.

( ) Capable of extremely high work output. Can perform at highest rate.

B. How good is the quality of his work? (Ability to organize problems for machine solution, prepare essential data, and develop detailed instructions in conformance with quality standards.)

( ) The grade of work could stand improvement. Performance is usually acceptable, but only meets minimum standards.

( ) Performance is acceptable, but usually not superior in quality.

( ) Performance is usually superior in quality.

( ) Performance is almost always of the highest quality.

( ) Performance always meets maximum standards.

C. How much does he know about his work? (Understanding of the principles, methods, equipment, and materials that have to do directly or indirectly with his work.)

( ) Has little knowledge. Does not know enough to do adequate work.

( ) Has limited knowledge. Knows enough to "get by".

( ) Has moderate knowledge. Knows enough to do fair work.

( ) Has broad knowledge. Knows enough to do good work.

( ) Has complete knowledge. Knows work thoroughly.

D. How complete is his understanding of mathematics? (Ability to make necessary computations required to perform his work.)

( ) Fair understanding. Computes the less difficult mathematics involved.

( ) Satisfactory understanding. Computes most of the mathematics involved.

( ) Very good understanding. Computes all but the most difficult mathematics involved.

( ) Excellent understanding. Computes all of the mathematics involved.

( ) Outstanding understanding. Computes complex problems involving theoretical mathematics.

E. How accurate is he in his work? (Ability to avoid making errors in the development and preparation of program instructions.)

( ) Makes many errors. Work needs constant checking.

( ) Makes frequent errors. Work needs more checking than is desirable.

( ) Makes errors occasionally. Work needs only normal checking.

( ) Makes few errors. Work seldom needs checking.

( ) Rarely makes an error. Work almost never needs checking.

F. How well and accurately does he communicate with others? (Ability to understand and give instructions; or to obtain and transmit facts and ideas graphically, orally, and in writing.)

( ) Has some difficulty in maintaining clear communication with others.

( ) Has a little trouble with communication. Sometimes confuses others.

( ) Satisfactory. Usually gives and takes information fairly accurately.

( ) Better than average. Seldom has any difficulty with communication.

( ) Excels in understanding and making himself understood.

G. How resourceful is he when something different comes up or something out of the ordinary occurs? (Ability to apply what he already knows to a new situation. Ability to make independent judgements and decisions.)

( ) Often has difficulty handling new situations. Needs help on all but simple problems.

( ) Sometimes knows what to do, sometimes doesn't. Can deal with problems that are not too complex.

( ) Usually able to handle new situations. Needs help on only complex problems.

( ) Practically always figures out what to do himself. Rarely needs help.

( ) Always figures out what to do. Never requires help.

H. How many practical suggestions does he make for doing things in better ways? (Ability to improve work methods.)

( ) Sticks strictly with the routine. Contributes nothing in the way of practical suggestions.

( ) Slow to see new ways to improve methods. Contributes few practical suggestions.

( ) Neither quick or slow to see new ways to improve methods. Contributes some practical suggestions.

( ) Quick to see new ways to improve methods. Contributes more than his share of practical suggestions.

( ) Extremely alert to see new ways to improve methods. Contributes a large number of practical suggestions.

I. How much aptitude or facility does he have for this kind of work? (Worker's adeptness or knack for performing his work easily and well.)

( ) Has great difficulty doing his work.Not suited to this kind of work.

( ) Usually has some difficulty doing his work. Not too well suited to this kind of work.

( ) Does his work without too much difficulty. Fairly well suited to this kind of work.

( ) Usually does his job without difficulty. Well suited to this kind of work.

( ) Does his work with great ease. Exceptionally well suited for this kind of work.

J. Considering all the factors already rated, and only these factors, how acceptable is his work? (Worker's "all-around" ability to do his work.)

( ) Of limited value to the organization. Performance somewhat inferior.

( ) A fairly proficient worker. Performance generally acceptable.

( ) A very good worker. Performance is acceptable.

( ) A valuable worker. Performance usually superior.

( ) An unusually competent worker. Performance outstanding.

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FACT SHEET

Job Title: Programmer, Engineering and Scientific (profess. & kin.)
020.188-030

Job Summary: Develops procedures and prepares diagrammatic plans and written instructions for solution of engineering and related scientific problems by means of automatic data-processing equipment.

Work Performed: Develops procedures and prepares diagrammatic plans and written instructions for solution of engineering and related scientific problems by means of automatic data-processing equipment. Receives documented work statement and related data, sketches, or blueprints from Engineer or Scientist requesting computer program. Studies work statement and related data to become familiar with nature and scope of assigned project. Identifies mathematical formulas, equations, and assumptions presented in support of problem. Ascertains extent and type of information to be processed and considers final output format. Makes decision on which procedural routine to utilize for computer processing. Examines data and related documentation to define problem in terms of desired results and availability of data. Analyzes problem, working with scientific and mathematical formulas, tables, and reference materials; and prepares, as necessary, charts, tables, and diagrams to assist in analysis. Makes analytical and logical analysis to identify and define each detail of mathematical computations or technical elements of problem and to arrange computations and elements into logically inevitable or predictable interrelationship and sequence. Reviews procedural routine, and ascertains that routine selected will be capable of being carried out within computer limitations. Analyzes and plans program to minimize required storage space and computer running time. Develops diagrammatic plans, and prepares instructions for console operator. Defines elements of problem to be entered as input data, and prepares input data list. Defines elements of information which will appear in output, and prepares output data list setting forth output format. Develops block diagrams and detailed flow charts to depict manner in which each mathematical and technical computation will be sequenced and to establish continuity of progression by which computer operations will copy data, process data, and print solution. Translates each flow chart step into machine or problem-oriented language, and writes detailed coded instructions for subsequent transfer of instructions to punch cards, punch tape, or magnetic tape. Prepares set of operating instructions for console operator. Prepares and submits program report to supervisor for review and approval. Reviews and tests program for accuracy, completeness, and consistency. Prepares set of sample data or sub-routine for computer run to verify accuracy and completeness of program. May, on occasion, operate computer to check program. Keeps abreast of new developments, and refers to technical literature in the field of computer programming. Attends company sponsored conferences, institutes, or meetings and participates in discussions of program approaches for new and improved types of computers.

Effectiveness of Norms: Only 68% of the nontest-selected workers used for this study were good workers; if the workers had been test-selected with the S-316 norms, 83% would have been good workers. 32% of the nontest-selected workers used for this study were poor workers; if the workers had been test-selected with the S-316 norms, only 17% would have been poor workers. (Validation sample.)

Only 71% of the nontest-selected workers used for this study were good workers; if the workers had been test-selected with the S-316 norms, 81% would have been good workers. 29% of the nontest-selected workers used for this study were poor workers; if the workers had been test-selected with the S-316 norms, only 19% would have been poor workers. (Cross-Validation sample.)

Applicability of S-316 Norms: The aptitude test battery is applicable to jobs which include a majority of duties described above.

GPO 865-004